

Resuspension of Fibers from Flooring Surfaces Due to Human Activity

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ABSTRACT

The World Trade Center (WTC) collapse on 9/11 and the subsequent cleanup released a large particulate loading (dust) into the environment proximal to the WTC complex. This dust included building materials, such as asbestos and manmade vitreous fibers. Although much of the dust deposited outdoors, a significant quantity penetrated into residences and businesses in the surrounding area. As the resuspension of particles from human activities, such as walking and vacuuming, could result in unhealthy air concentrations in the immediate vicinity of activity and as these particles may translocate to other indoor locations and surfaces within a residence, a study was designed to better assess potential exposures to WTC-derived fibers due to resuspension.

This research sought to relate carpet concentration (loading) of asbestos-type fibers to the concentration of fibers resuspended in indoor air during normal human activities. To achieve this objective, the work investigated fiber resuspension from carpeted flooring surfaces due to human activities, such as walking and vacuuming, in relation to vertical height. Additionally, relationships were developed (emission factors) between resuspended fibers and fiber concentration present in the carpeted surface (loading). Finally, a comparison was performed of current sampling/analysis methods for fibers in carpets including microvac (ASTM Method 5755-95), ultrasonication, and scanning electron microscopy. During this study, the effect of variables, such as carpet age, carpet wear, and relative humidity, on resuspension of fibers was considered.

This work was a collaborative effort between U.S. EPA/ORD, U.S. EPA Region 2, and RTI International. The results of this study will assist in the management of exposure from catastrophic events, such as occurred at the WTC site, in addition to building demolition and asbestos contamination situations. Additionally, these results will aid in the development of risk-based clearance criteria for asbestos in settled dust on porous surfaces. While surface sampling for asbestos is readily accomplished, data relating asbestos load to indoor air concentration is a critical step in assessing the potential risk posed by asbestos in settled dust. Thus, this research has provided valuable data on the basic relationship between fiber loads in carpets and indoor air as well as useful information on the factors that influence that relationship such as carpet sampling methods, air sampling location, loading, carpet age, activity patterns (e.g., walking, vacuuming), and relative humidity.

METHODS

- New and old 3' x 3' carpet was seeded with Wollastonite.
- Seeded carpet was placed in uniform flow chamber (Figure 1).
- Subject walked and vacuumed carpet inside chamber for 5 minutes.
- Sampling ports allowed isokinetic sampling from the test space.
- Temperature and relative humidity were monitored.
- Airborne fiber concentration and size distribution samples taken.
 - Size Distribution - Aerodynamic Particle Sizer, TSI Inc., St. P
 - Mass/Concentration - URG Mass Filter Sampler, URG Inc.,
- Carpet loading determined by:
 - Scanning Electron Microscopy (SEM)
 - Microvac (ASTM Method 5755-95)
 - Ultrasonication (Millette et al., 1993)

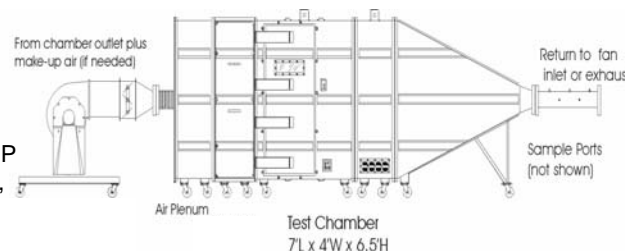


Figure 1

- Emission factor = $\frac{\text{Airborne fiber concentration} \times \text{Room volume}}{\text{Carpet loading} \times \text{Walking area}}$

RESULTS

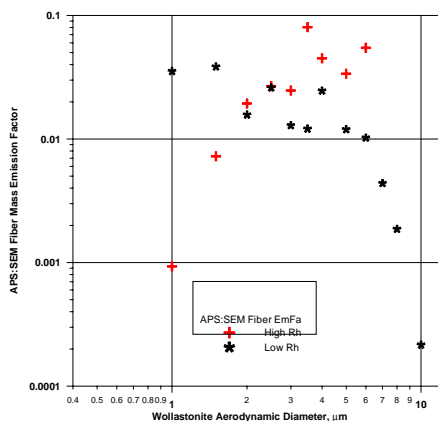


Figure 2: Mass Based Emission Factor by Aerodynamic Diameter for High and Low RH

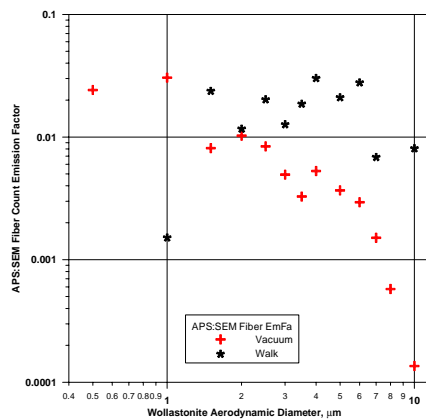


Figure 3: Count Based Emission Factor by Aerodynamic Diameter for vacuuming and walking

- Size dependent fiber emission factors generally fell between 0.01 and 0.10 $\mu\text{g}/\mu\text{g}$ for walking (both count and mass).
- K-factors ranged from 10^{-3} to 10^{-6} for walking.
- RH and carpet age/wear had a significant affect on fiber resuspension.
 - At low RH (40%), fiber emission factors from new carpet were significantly lower than those from older, worn carpets.
 - For aerodynamic diameters ≥ 2 microns, emission factors for new carpet at higher RH (90%) were up to four times greater than for new carpet at lower RH. For aerodynamic diameters < 2 microns, the reverse trend was seen, with emission factors for new carpet greater at lower RH (Figure 2).
- Vacuuming of both new and old carpets resulted in lower emission factors than walking on the carpet (Figure 3).
- Comparison of sampling/analysis methods for fibers in carpets showed that the microvac technique best estimated particulate available for resuspension, with SEM analysis accurate only for new carpets, and ultrasonication overestimating available PM.

CONCLUSIONS

This study provides data on the basic relationship between fiber loads in carpets and indoor air as well as useful information on the factors that influence that relationship such as carpet sampling methods, air sampling location, loading, carpet age, activity (e.g., walking, vacuuming), and relative humidity. The results of this study will assist in the management of exposure from catastrophic events, building demolition and asbestos contamination situations.



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